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PRODUCT INFORMATION

TEXTILE ROPE

Inspection and Discard Synthetic Fibre Ropes

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Fact Sheet

Inspection and Discard Synthetic Fibre Ropes

Safety...

What we produce and supply needs special care...,
...Care about consequences in case of failure.
It's not just quality, it's safety that matters.

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General

The decision to discard, repair or continue using a rope mooring hawser can never be taken on the grounds of exact standards. For correct use of the criteria given here general knowledge of, and experience with, fibre ropes in general and rope hawsers in particular are essential. In case of doubt it is advised to consult the rope manufacturer.

In general, mooring hawsers can be rejected because of:

- Failure: Mooring forces were exceeding the maximum design force. This is unlikely, assuming a sound design basis.
- Chemical deterioration: Unlikely for existing operations. Any problem should already been identified.
- Fatigue: The fatigue life of ropes is excellent, see curve. With normal safety factors (2 to 3,5) the rope should not fail because of fatigue loading.
- Hawser damage. This will be discussed here.

Therefore evaluating the rope damage can primarily assess Safe Working Life of the rope. As a guideline the Residual Breaking Strength of the damaged rope should not be less than 75 % of the New Breaking Strength. Consequently, the number of cycles (tanker discharges) are expected to be the main driver for mooring hawser disposal. However, this principle should be well understood.

Inspection

The lifetime of a rope is strongly influenced by its construction, the environment it is used in and the type of application.

Typically the Safe Working Life of the mooring hawser can be expressed in the number of operations the hawser has seen and the conditions of the operations. Thus for a good estimate it is recommended to keep a logbook of the number of operations and the environmental conditions thereof.

Inspections can then be conducted after an agreed number of operations. In general it is recommended to conduct eight inspections over the expected / estimated lifetime of the hawser.

In general the damage of the rope is repetitive. Therefore, using this experience an operator will probably be able to identify the area(s) of the rope where damage is most likely to occur, for example the one end of the rope is handled most. In that case an inspection can concentrate to that area.

The residual breaking strength of the rope should be quantified using the procedures described below in order to obtain a clear view of the strength decay and remaining lifetime.

Discard criteria

The following factors may warrant removing a rope prematurely from service:

- wear and abrasion
- friction burns
- creep
- crushing/pinching
- local damage
- pulled cover braid yarns or strands
- cut yarns or strands
- others

If local damage is observed then a length of 50 times the diameter before and after that position should be closely inspected and all reductions in strength should be added together.

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Wear and abrasion
Wear and abrasion are the most common causes of rope failure. Rough surfaces, sharp edges, burrs, rust and dirt can cause serious damage to a rope. Winches, pulleys, chocks, bits, etc. should be clean and in good condition.

Wear and abrasion can occur over greater lengths or locally. Particular attention should be paid to the splice area and the eye.

Frayed and broken yarns should be removed and the damaged area should be estimated.

Friction burns
Friction burns can occur over greater lengths or locally. Direct contact with hot objects should always be avoided (e.g. exhaust pipes). Also when using the rope on a winch, capstan, sheaves, etc. care should be taken to avoid surging the rope while it is under load. When the rope slips a lot of heat can be generated through friction.

When friction burns are detected, then the rope should be opened and it should be estimated how much of the rope is fused. The damaged area should be considered to be about twice the fused area.

Crushing/pinching
When a rope has been crushed or pinched it should be removed from service. Typically with this type of problem the resulting damage in the rope is a combination of broken/cut yarns and pulled yarns or strands, which makes for very unreliable estimates of the resulting reduction in strength. A knot has a similar effect.

Local damage
Depending on the extent of localised damage it may be possible to repair the rope rather than remove it from service. Options include local repair plus downgrading or removal of the damaged section and re-splicing.

A second, independent evaluation by a competent person (e.g. the rope manufacturer) is strongly recommended before re-splicing.

Pulled yarns or strands
Individual yarns or strands can be caught behind objects (nails, burrs, etc.) and be pulled out of the rope. This damage makes the rope very unsafe, because the pulled yarns can easily snag behind an object. Thus care should be taken to work the yarn or strand back into the rope.
If a cover yarn is pulled and the pull is too severe, the yarn can be cut and the ends worked back into the rope. A pulled core yarn or strand should not be cut. Rather, the pull should be buried back into the interior of the rope.

The number of pulled yarns or strands should be counted and noted in the inspection card. The cause should be traced and alleviated.

Cut yarns or strands
Individual yarns or strands can be cut through chafing against sharp objects (e.g. the side of a steel plate).

The number of cut yarns or strands should be counted and the damaged area per strand estimated.

Others
No attempt is made here to list a complete catalogue of discard criteria. Many different types of damage to a rope are possible. Thus common sense during inspection to assess the Residual Strength is paramount.

Estimating residual strength
The Breaking Strength of a rope is reduced by damage to the rope yarns. Through inspection this reduction in strength is estimated per damaged spot. All damages over the inspected length of the rope should then be added together. On the basis of that total estimate the rope is downgraded or removed from service.

On specific request the manufacturer can complete a residual lifetime assessment for a discarded mooring hawser. The result can be used as input for further future lifetime assessments. Typically a length of 2 meter is sufficient This assessment is considered to be effective and fully comparable with a full hawser break test.

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EVALUATION GUIDE

DEFINITIONS

8-stand = 8-stand plaited ropes		**Damage Description =** A brief description of types of damage.
3-strand = 3 and 4 strand laid ropes		**Repair - Yes =** Repair must be made to justify **No** recommendation in **Retire** column. See Section 7.2. Repairs may not be feasible in some cases.
All braids = 8 and 12 strand single braids and double braids		**Downgrade** - Ropes may find use in a less demanding or critical application. This is not recommended, however.
Jacketed = Jacketed ropes with wire lay, parallel sub-rope, parallel strand or parallel fiber load bearing cores		**Retire - Yes =** Do not use for original application. **- Best action =** Preferred that rope be downgraded or retired.

A. INITIAL EVALUATION - GENERAL

Rope type	Damage Description	Repair	Downgrade	Discard
All ropes	Rope displays moderate wear. No history of use, no records or no specifications. Time in service unknown. No severe damage. Potential personal injury or material damage exists if rope should break.	No	Possible	Best action

B. EXCESSIVE TENSION / SHOCK LOADING

Rope type	Damage Description	Repair	Downgrade	Discard
All ropes	History of excessive tension (for example, over 50% of published strength) or shock loading. No visible damage.	No	Possible	Best action
3-strand 8-strand All braids	Visible damage; i.e., broken strands, splice slippage,measurable creep or internal fusion. History of excessive tension or shock loading.	No	No	Yes
All ropes	Back of eye flattened and hard; cannot be softened	No	Possible	Best action

C. CYCLIC TENSION WEAR

Rope type	Damage Description	Repair	Downgrade	Discard
All braids	Broken or seemingly cut outer filaments that are packed into the surface or protrude, uniformly over working length. Fuzzy appearance uniform over length. Broken internal filaments over length. Packing of broken filaments that hardens rope giving less than normal flexibility; rope cannot be pried open for internal inspection.	No	Possible	Best action
3-strand 8-strand	Broken, powdered or matted filaments at strand rub areas at center of rope. Twist or compress rope to expose interior between stands.	No	Possible	Best action
Jacketed Kernmantle	Broken filaments on interior filaments of core rope. Fusion or hard spots on core. Powdered, broken or matted filaments at cover/core interface.	No	No	Yes

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D. EXTERNAL ABRASION

Rope type	Damage Description	Repair	Downgrade	Discard
Double braids	Outer braid worn away by less than 10% of the circumference or 10% over one fourth of strands along the length; core not exposed significantly.	No.	Possible	Best action
Double braids	Outer braid worn away by more than 10% of the circumference or over one fourth of the strands along the length; core exposed.	No	No	Yes
3-strand 8-strand plait 12-strand braid	10% loss of fiber cross-section in whole rope or in an individual strand cross- section. Crowns of strands badly worn reducing strand diameter by more than 10%.	No	Possible	Best action
All ropes	Localized hard or burn areas, area less than 15% of rope circumference in width; penetration less than 5% of rope diameter.	No	No	No
All ropes	Localized hard or burn areas, area more than 15% of rope circumference in width; or length in excess of one half number of strands; and penetration more than 5% of rope diameter.	No	No	Yes
Jacketed Kernmantle	Load bearing component (core of jacketed rope) is damaged by more than 5% of the cross sectional area.	No	Not recommende d	Best action
Jacketed or Kernmantle - Jackets	When core undamaged, non-load bearing jacket abrasion assessment depends on the criticality of coverage for a particular application. Loss of 10% of strands at one area is cause for concern but occasional breakage of jacket strands along length is probably not so critical.	Not recom-mended	Possible	Case by case

E. CUTTING

Rope type	Damage Description	Repair	Downgrade	Discard
Double braids	Outer braid cut by less than 5% of the circumference or 10% of diameter of one fourth of number of total strands along one cycle length; core not exposed.	Tuck loose ends	No	No
Double braids	Outer braid cut by more than 5% of the circumference or 10% of diameter of one fourth of number of total strands along one cycle length; core not exposed.	No	No	Yes
3-strand 8-strand plait 12-strand braid	10% loss of fiber cross-section in whole rope or in an individual strand cross-section	No	Possible	Best action
3-strand 8-strand plait	Over 10% loss of fiber cross-section section in whole rope or in an individual strand cross-section	No	No	Yes
Jacketed	Loadbearing component (core of jacketed rope) is damaged by more than 5% of the cross sectional area.	No	Possible	Best action
Jacketed Ropes - Jackets	Core undamaged. Jackets are not load bearing. Damage assessment depends on the criticality of coverage for a particular applications. Also, jackets might be repaired .	Possible	Possible	Case by case

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F. PULLED STRANDS AND YARNS

Rope type	Damage Description	Repair	Downgrade	Discard
3-Strand 8-Strand	Rope yarns may be pulled out from main strands. Less than 10% of rope yarns in a strand are out of place	Yes	No	No
8-Strand Braids	Main strands, less than 15% of number present are pulled out of position a moderate amount can be worked back into the rope to conform to the original structure	Yes	No	No
8-Strand Braids	Main strands are pulled out of position, more than 20% of number present or so much that they cannot be worked back into the rope to conform to the original structure	No	Possible	Best action
Double braids Jacketed ropes	Inner core protrudes through jacket. Rope can be massaged back into original structure without kinking.	Yes	Possible	Best action
Double braids Jacketed ropes	Inner core protrudes through jacket. Rope cannot be massaged back into original structure without kinking. displays moderate wear	No	No	Best action

G. FLEX WEAR ON PULLEYS, ROLLERS, CHOCKS AND FAIRLEADS

Rope type	Damage Description	Repair	Downgrade	Discard
All braids	Broken outer filaments that are packed into the surface with fuzzy appearance uniform over flex length. Broken internal filaments over flex length. Packing of broken filaments that hardens rope giving less than normal flexibility; rope cannot be pried open for internal inspection. Non-recoverable flattening.	No	Possible	Best action
3-strand 8-strand	Broken filaments and evidence of wear on strand crowns on surface on flex length. Broken filaments and powder at strand rub points at center of rope. Internal fusion.	No	Possible	Best action
Jacketed	Broken filaments and evidence of wear on surface in flex length. Broken filaments on interior filaments of core rope. Fusion or hard spots on core. Powder or broken filaments at cover/core interface. Figure shows core with jacket removed.	No	No	Yes

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H. SPLICED EYE – WEAR, FABRICATION, THIMBLES

Rope type	Damage Description	Repair	Downgrade	Discard
All ropes	Improperly made splices. Check for correct fabrication. Refer to qualified person, manuals or published procedures. Old splice can be cut out and new one made.	Yes	Possible Splices in used rope often not reliable	Best action
All Ropes	Surface abrasion or cut damage in splice eye. See Sections C & D above	No	Possible	See C & D
3-strand	Splice has slipped. Strand tails have pulled back	Yes	Possible	Best
8-strand Braids	into rope. Old splice can be cut out and new one made.		Splices in used rope often not reliable	action
Braids	Leg junction shows cut or ragged strands. Old splice can be cut away and new splice made	Yes	Possible Splices in used rope often not reliable	Best action
All ropes	Damaged or improper splice cannot be remade with confidence that strength is not compromised.	No	No	Yes
Thimbles	Thimbles have sharp edges or corrosion. Thimble loose in eye. Rope does not fit thimble. Thimble can be replaced. Assess rope damage in accordance with Sections C & D.	Yes	No	No
Thimbles	Thimbles may be required. Eye damage may be occur because thimble is not used. Minor rope damage is present; thimble can be added.	Yes	No	No
Other Termin-ations	Mechanical, potted and terminations other than splices with or without thimbles should be verified as to strength capability. Action as indicated if in doubt unless fitting can be replaced by splicing.	No	No	Yes

I. KNOTS

Rope type	Damage Description	Repair	Downgrade	Discard
All Ropes that can be spliced	A knot has been used instead of a splice and cannot be removed or replaced by a splice. No damage at knot. Assume strength has been reduced 50% and calculate working load limit on this basis - compare to actual and check if greater.	No	Possible	Best action
All Ropes that can be spliced	Knot/s have been placed in body of rope between splices and cannot be removed without damage or, if they are, the length previously in the knot is abraded or kinked.	No	No	Yes
Ropes for use with knots, not spliceable	Working load limit is based on 50% of published breaking strength. Little (10% or less) fiber damage at knot.	No	No	No
Ropes for use with knots, not spliceable	Working load limit is based on 50% of published breaking strength - compare to actual and found not acceptable or there is in excess of 10% fiber damage at knot.	No	Possible	Yes

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J. CREEP (cold flow)

Rope type	Damage Description	Repair	Downgrade	Discard
All ropes	Rope is very close to or exceeds the creep limit set by the user or rope maker. Creep is checked by procedures set by user or rope maker and found to be near limit.	No	No	Yes
All Ropes	Rope type is subject to creep and history of use shows that it may have experienced excessive creep. Rope has been used for extended time at high loads expected to cause creep.	No	Possibly	Best action

K. AXIAL COMPRESSION AND KINK BANDS

Rope type	Damage Description	Repair	Downgrade	Discard
Jacketed	Body of rope shows distinctive periodic bulges along its length. Internal inspection is not possible.	No	Possible	Yes
Jacketed	Internal inspection reveals distinctive Z shaped kink bands in portions of the load bearing core. More than 10% of the cross section is affected. These tend to repeat in a regular pattern along the length	No	No	Yes
Splices	Splices in ropes made of high modulus fiber may exhibit kink bands. Damage is very difficult to access without destructive testing.	No	No	Yes

L. HOCKLE, TWIST, KINK OR CORKSCREW

Rope type	Damage Description	Repair	Downgrade	Discard
3-strand Ropes	A loop has been pulled tight causing hockle; rope structure cannot be turned back easily without leaving the rope distorted.	No	No	Yes
3-strand Ropes	3-strand ropes display a corkscrew appearance when laid out straight and without tension. Corkscrew can be removed by twisting in opposite direction.	Yes	No	No
3-strand Ropes	3-strand ropes display a corkscrew appearance when laid out straight and without tension. Corkscrew cannot be removed by twisting in opposite direction (often result of bad splice or manufacturing defect).	No	Possibly	Best action
3-strand Ropes	Rope is unlaid (strands do not stay together).	No	No	Yes
3-strand	Swivel has been used with 3-strand ropes	No	No	Yes
8-strand All braids	Rope has been used in series with wire rope without a swivel (unless wire is non-rotating)	No	No	Yes
Braided and plaited ropes	Discernable twist when laid out straight, even under tension. Twist can be removed by twisting in opposite direction.	Yes	No	No
All ropes	Kinking is present. Kink will not disappear completely when slight tension is applied or springs back when tension is removed. Rope is hard and flattened at kink.	No	No	Yes

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M. SUNLIGHT DEGRADATION

Rope type	Damage Description	Repair	Downgrade	Discard
Polypropylene Ropes	Polypropylene rope with many brittle and broken filaments on the surface	No	No	Yes
All ropes without non-load bearing jackets	Ropes less than 1 inch diameter that are known to have had extensive exposure (year or more) to bright sunlight. Especially nylon, aramid and polypropylene.	No	Possible	Best action
All ropes with non-load bearing jackets	Jacket completely covers the rope, or can be patched to cover the rope, and is not subject to severe wear. Underlying core has been protected.	Yes	No	No
All ropes with non-load bearing jackets	Jacket appears severely affected and cannot be repaired. Jacket shows signs of sunlight degradation and is subject to rough service.	No	No	Yes

N. CHEMICAL AND HEAT DEGRADATION

Rope type	Damage Description	Repair	Downgrade	Discard
All Ropes	Known that there has been significant exposure to chemicals and/or high temperatures. No information from qualified persons or rope manufactures	No	No	Yes
All ropes	Discoloration, brittle fibers, fusion, bonding of fibers together, hardness. Chemical exposure is suspected.	No	No	Yes
Nylon rope	Rope has been used or stored when wet in contact with iron or steel that is rusted. Rope is reddish or brown. The condition has existed for an extended period.	No	No	Yes

Source: Evaluation Guide Cordage Institute International Guideline CI 200104